Claims

1. Computer-assisted modelling method for the behavior of a steel volume (1) with a volumetric surface,

- in which a computer (4) on the basis of an instantaneous initial state (ZA) of the steel volume (1) and at least one instantaneous influence quantity (W) operating via the volumetric surface on the steel volume (1), by resolving a thermal conduction equation and a phase change equation, determines a subsequent state (ZF) of the steel volume (1),
- in which the at least one influence quantity (W) includes one local influence for a number of surface elements (10)) of the volumetric surface in each case and the local influences operate via the relevant surface element (10) on the steel volume (1),
- in which the initial state (ZA) and the subsequent state (ZF) for a number of volume elements (9) of the steel volume (1) comprise local proportions (p1, p2, p3) of modelled phases of the steel and a quantity (H) describing a local energy content of the steel,
- in which the modelled phases of the steel comprise austenite and a first further phase, into which austenite can be changed and which can be changed into austenite

characterized in that

- the initial state (ZA) and the subsequent state (ZF) for at least one of the volume elements (9) also comprise a local distribution in concentration (K) of at least one mobile alloy element in the steel,
- within the context of the change equation it is determined for the at least one volume element (9) which concentrations (k1, k3;k2, k4) of the at least one mobile alloy element are present on both sides of a first phase boundary (11, 12) between austenite and the first further phase,

- by resolving a first Stefan problem it is determined whether and how the distribution in concentration (K) of the at least one mobile alloy element changes in the austenitic zone of the volume element (9) observed and whether and to what extent (δx, δx′, δx") the first phase boundary (11, 12) is displaced thereby, and
- the local proportions (p1, p2, p3) of the phases are determined on the basis of the position of the first phase boundary (11, 12) defined by the extent (δx) of the displacement of the first phase boundary (11, 12).

2. Modelling method in accordance with claim 1, c h a r a c t e r i z e d i n t h a t

- the modelled phases of the steel also comprise a second further phase into which austenite can be changed and which can be changed into austenite.
- for the volume element (9) observed, it is also determined within the context of the change equation which concentrations (k2, k4; k1, k3) of the at least one mobile alloy element are present on both sides of a second phase boundary (12, 11) between austenite and the second further phase,
- through additional resolution of a second Stefan problem it is determined whether and how the distribution in concentration (K) of the at least one mobile alloy element changes in the austenitic zone of the volume element (9) observed and whether and to what extent (δx", δx′) the second phase boundary (12, 11) is displaced by this,
- the Stefan problems are coupled to each other,
- square measures (F1, F2) are assigned to the phase boundaries (11, 12),
- a proportion (q) of the square measure (F2) assigned to the second phase boundary (12) is determined from the sum of the square measures (F1, F2) and

- the local proportions (p1, p2, p3) also depend on the proportion (q) of the square measure (F2) assigned to the second phase boundary (12) in the sum of the square measures (F1, F2).

3. Modelling method in accordance with claim 2, characterized in that the proportion (q) of the square measure (F2) assigned to the second phase boundary (12) in the sum of the square measures (F1, F2) is determined such that the phase boundaries (11, 12) always remain arranged alongside one another.

4. Modelling method in accordance with claim 2, characterized in that, the proportion (q) of the square measure (F2) assigned to the second phase boundary (12) in the sum of the square measures (F1, F2) is adjusted such that the phase boundaries (11, 12) move towards each other.

5. Modelling method in accordance with claim 2, 3, or 4, characterized in that, on the basis of the proportion (q) of the square measure (F2) assigned to the second phase boundary (12) of the sum of the square measures (F1, F2) it is deduced whether austenite changes only in the first further phase, only in the second further phase or both in the first and also in the second further phase.

6. Modelling method in accordance with one of the above claims,
characterized in that,

- the volume element (9) observed is embodied as a cuboid and has three basic dimensions (A, B, C),
- the first phase boundary (11, 12) is embodied as a rectangle with a first longitudinal side and a first transverse side and
- the first longitudinal side corresponds to one of the

first basic dimensions (A, B, C), the first transverse side runs in parallel to a second of the basic dimensions (A, B, C) and displacements (δx′, δx″) of the first phase boundary (11, 12) occur in parallel to the third of the basic dimensions (A, B, C).

7. Modelling method in accordance with claim 6 and one of the claims 2 to 5,

characterized in that

- the second phase boundary (12, 11) is embodied as a rectangle with a second longitudinal side and a second transverse side and
- the second longitudinal side corresponds to the first of the basic dimensions (A, B, C), the second transverse side runs in parallel to the second of the basic dimensions (A, B, C) and displacements (δx″, δx′) of the second phase boundary (12, 11) occur in parallel to the third of the basic dimensions (A, B, C).

8. Modelling method in accordance with claim 7, characterized in that the sum (l) of the transverse sides of the phase boundaries (11, 12) is roughly the same as 1.5 to 3 times a critical lamella spacing (l′), in which an energy balance is undertaken which takes account on the one hand of the phase changes of the steel corresponding to the displacement of the phase boundaries (11, 12) and on the other hand takes account of the changes in the surface of a boundary layer (16) between the first and the second further phase corresponding to the displacement of the phase boundaries (11, 12).

9. Modelling method in accordance with one of the above claims,

characterized in that the Stefan problem is formulated

and resolved in one dimension or the Stefan problems are formulated and resolved in one dimension, and that the proportion (p3) of austenite is determined on the basis of a non-linear function of the location of the phase boundary (11, 12) or of the phase boundaries (11, 12).

10. Modelling method in accordance with one of the above claims,
characterized in that the concentrations (k1 to k4) in which the at least one mobile alloy element is present on both sides of the first phase boundary (11, 12) or on both sides of the first and both sides of the second phase boundary (11, 12) are determined on the basis of the Gibbs free enthalpies (G1, G2, G3) of the phases.

11. Modelling method in accordance with one of the above claims,
characterized in that on the basis of the phases already present in the initial state (ZA) and on the basis of the Gibbs free enthalpies (G1, G2, G3) of the phases, it is determined whether both austenite and also the first further phase are present or whether in addition to austenite and the first further phase, the second further phase is also present.

12. Modelling method in accordance with one of the above claims,
characterized in that the steel volume (1) comprises a multiple of the volume elements (9) that the Stefan problem or the Stefan problems will only be resolved for a part of the volume elements (9) and that the local proportions (p1, p2, p3) of the phases of the other volume elements (9) are determined on the basis of the local proportions (p1, p2, p3) of the phases of the part of the

volume elements (9).

13. Modelling method in accordance with claim 12, characterized in that the thermal conductance equation is resolved individually for each volume element (9).

14. Modelling method in accordance with one of the claims 1 to 13,

characterized in that,

- an initial state (Z) and at least one desired end value (f'*) are specified to the computer (4),
- the modelling method is applied iteratively in accordance with one of the claims 1 to 10,
- the initial state (ZA) of the first iteration corresponds to the first state (Z) and the initial state (ZA) of each further iteration to the subsequent state (ZF) determined immediately beforehand and
- on the basis of the subsequent state (ZF) determined after a last iteration, an expected end quantity (f') is determined and compared with the desired end quantity (f'*).

15. Modelling method in accordance with claim 14, characterized in that it is executed on-line and in real time or offline.

16. Modelling method in accordance with claim 14 or 15, characterized in that the influence quantities (W) of the iterations correspond in their entirety to an influence quantity sequence, that the computer (4) varies the influence quantity sequence on the basis of the comparison of the expected end quantity (f') with the desired end quantity (f'*) and starting from the first state (Z) executes the modelling method again in accordance with claim 12 until at least the expected end quantity (f') corresponds to the desired end

quantity (f'*).

17. Modelling method in accordance with one of the claims 1 to 13,
characterized in that it is executed online and in real time, that the computer (4) determines the influence quantity (W) on the basis of an initial quantity (f) determined from the initial state (ZA) and a desired subsequent quantity (f*) and that the computer (4) activates an influencing device (2) such that the steel volume (1) is influenced in accordance with the influence quantity (W) determined.

18. Data medium with a computer program (6) stored on the data medium for executing a modelling method in accordance with one of the above claims.

19. Computer with mass storage (8), in which a computer program (6) is stored, so that when the computer program (6) is called, a modelling method in accordance with one of the claims 1 to 17 can be executed.

20. Influencing device for influencing the temperature of a steel volume (1), especially cooling line,
characterized in that it is controlled by a computer (4) in accordance with claim 19.

21. Steel
characterized in that it has to pass through an influencing device (2) in accordance with claim 20, with the influence quantity (W) having being determined in accordance with claim 16 or 17.